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Effect of Soil Physical Properties on Natural Regeneration of Populus caspica Bornm. and Alnus glutinosa L. in Northern Iran

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Abstract. *Populus caspica,* as endemic and endangered poplar species, and *Alnus glutinosa* as a native species in most of Europe and locally in southwest Asia, are the most important tree species naturally disturbed in plain areas in North of Iran. Although the natural regeneration of *Alnus glutinosa* show good situation, unfortunately natural regeneration, distribution and elite trees of *Populus caspica* were diminished by different reasons. In this study, natural regeneration conditions of these species and their relationships with physical soil properties were carried out in two regions, with poor and good natural regeneration. Sampling have been done randomly in unequal linear transect. In each sampling plot, diameter of breast height for each tree and soil sample was taken. For all of soil samples, soil texture, Bulk density (B.D), Particle density (P.D), and water holding capacity (WHC) were analyzed. Differences of quantitative characteristics of trees and soil properties between two plantations were analyzed based on independent samples t-test, and correlation between variables were determined by Pearson correlation coefficient. Results of this study showed that there was strong relationship between establishments of natural regeneration of *Populus caspica* with soil physical properties. Natural regeneration of *Alnus glutinosa* did not show any relationship with soil physical properties. Natural regeneration of *Populus caspica* was established better in light soil texture with good aeration.

Keywords: *Populus caspica*, Natural regeneration, Soil properties, North of Iran.

Introduction

The majority of the north of Iran is covered by the Caspian forest, a deciduous temperate commercial forest, of about 1.8 million ha located on the northern slopes of the Alborz Mountains overlooking the Caspian Sea (TABARI *et al*., 2011).

Populus caspica (Persian poplar), as endemic and endangered poplar species existed naturally in plain areas of Guilan province beside the planted species (ASADI & MIRZAIE-NODOUSHAN, 2011). Hyrcanian Forest is rich in biological diversity, with several endemic and endangered species. It contains the most important natural habitats for in-situ conservation of biological diversity in Iran, including those containing threatened species of outstanding universal value, from the view point of science or conservation (SADATI *et al*., 2010). *Populus caspica* (Salicaceae) is an endangered and endemic tree species (NAJAFI *et al*., 2012)

predominantly distributed in the Hyrcanian Forest. Nevertheless, there is little information about current site conditions for this species. This information is critically important for developing a conservation strategy.

Populus caspica species are commonly planted as fast-growing species in the world and some parts of plain areas in the north of Iran. (DICKAMANN & STUART, 1983) declared that *Populus caspica* could grow almost everywhere, but perform up to their full potential only on the best sites. Soil physical properties which play major roles in water holding capacity, aeration and root penetration, have a strong influence on the growth of poplars. As soil can effect poplar growth, these trees also affect different soil properties.

In the last years, the use of natural regeneration increases for following reasons: (1) decrease the costs of regeneration; (2) apply a ''close-to-nature'' kind of forestry, in which the use of smaller clear-cuts and naturally provided seeds are parts; and (3) increase plant density, get denser stands and hence improve the timber quality (HANSSEN, 2003). Light and soil condition are the main factors in natural regeneration and biodiversity of forest stand (AUBINA *et al*., 2008; BARBIER *et al*., 2008). Several researches for conifer stands had well documented that where canopy layer values were high, the cover of vascular plants and ground layer vegetation was reduced through shading (FAHY & GORMALLY, 1998). Overall more studies have reported that plantations of native or exotic timber species can increase biodiversity by promoting woody understory regeneration (PARROTTA, 1995).

JALILI & JAMZAD (1999) stated that in north of Iran the natural regeneration is reduced to different reasons. ASADI & MIRZAIE-NODOUSHAN (2011) stated that the seed breading of *Populus caspica* is found less in natural conditions.

Environmental factors such as temperature, moisture, soil conditions, topography, plant physiological conditions, seeding and seed viability have important roles in different plant species regeneration. ASADI & MIRZAIE-NODOUSHAN (2011) studied a seed collecting from 25 sites in north of Iran, and declared that seed germination and survival of seedling is depend to soil water content and appropriate light. SADATI *et al*. (2010) in their reviews stated that the loam texture soil is the reason of highest germinate.

In this study, natural regeneration conditions of *Populus caspica* and *Alnus glutinosa* and their relationships with physical soil properties were carried out in two regions, with poor and good natural regeneration. It is hypothesized that physical soil properties have effective role on natural regeneration of these species.

Materials and Methods

Study area. This study was carried out in two nearly regions called Safrabasteh forest park and Parkaposht in Guilan province (37˚19′ N, 49˚57′ E). These regions are on flat and uniform terrain in a plain area with the altitude of 10 m above sea level. Annual mean rainfalls and temperature are 1186 mm and 17.5°C respectively. Soil of the studied regions has neutral to low acidic reaction. Safrabasteh forest park is dominated by the natural forests containing native species such as *Alnus glutinosa, Pterocarya fraxinifolia, Populus caspica, Gleditschia caspica*. Parkaposht region, dominated by *Populus caspica* and *Alnus glutinosa*, is represented by *Populus caspica* regeneration.

Parkaposht is located in the sidelines in Sepidrood River with a significant level of 1.5 to 2 km in length and 300 to 400 m width.

Sampling method. Sampling was made randomly using unequal linear transect (AVEVY & BURKHAT, 2002) - 30 plots in each region were determined and total of 60 plots. In each sampling plot, after measuring of diameter of breast height for each tree, the number of regenerations was also recorded. Soil samples were taken in each plot, from 0-20 cm depth, and after mixing, one composed soil sample from each point was prepared (MARANON *et al*., 1999) and transferred to soil laboratory for analyzing.

Soil properties and statistical analyses method. All of soil samples were air-dried and passed through a 2 mm mesh. In the

lab, soil texture by hydrometer (BOUYOUCOS, 1962), bulk density (B.D) by clod method, water holding capacity (WHC), and particle density (P.D) by Pycnometer method (GHAZANSHAHI, 1999), were determined. Normality of variables was checked by Kolmogorov-Smirnov test and Levene's test was used to examine the quality of the variances. Differences of quantitative characteristics of trees and soil properties between two plantations were analyzed based on independent samples t-test (Student's t test at $p<0.05$), and correlation between variables were determined by Pearson correlation coefficient ($p<0.05$). For all statistical analysis, SPSS Software (version 17.0) was used.

Results

Number and diameter of trees in study regions. Mean comparison of the number of trees showed that there are significant differences between *Populus caspica*, *Alnus glutinosa*, *Populus* sp. and *Pterocarya fraxinifolia* in Safrabasteh forest park and region Parkaposht. Results suggest that *Populus caspica* and *Alnus glutinosa* are dominated trees compare to the other tree species in the studied region, although *Populus caspica* in Parkaposht and *Alnus glutinosa* in Safrabasteh forest park were dominated (Table 1). Based on the result, the mean diameter is higher both for *Populus caspica* and *Alnus glutinosa* in Safrabasteh forest park compared to Parkaposht (Table 2). Results of the *Alnus glutinosa* and *Populus caspica* species breeding are shown in Table 3. Based on the data obtained, the regeneration of *Populus caspica* is higher in Parkaposht compared to Safrabasteh forest park. Results did not show significant differences on *Alnus glutinosa* breeding.

Table 1. Mean±SD of trees number.

Species	Region	Mean±SD	t	Significance
Populus caspica	Parkaposht	6.97±3.47	9.149	0.000
	Safrabasteh forest park	1.03±0.76		
Alnus glutinosa	Parkaposht	2.7±1.95	-4.056	0.000
	Safrabasteh forest park	5.4±3.08		
Populus sp.	Parkaposht	1.27±1.17	3.963	0.000
	Safrabasteh forest park	0.00±0.00		
Pterocarya fraxinifolia	Parkaposht	0.00±0.00	-2.513	0.015
	Safrabasteh forest park	1.89±0.87		
Gleditschia caspica	Parkaposht	0.00±0.00	-1.415	0.163
	Safrabasteh forest park	0.07±0.25		

Table 2. Mean±SD of diameter at breast height (DBH)

Species	Region	Mean±SD	t	Significance
Populus caspica	Parkaposht	23.5±8.6	-21.576	0.000
	Safrabasteh forest park	138.7±51.3		
Alnus glutinosa	Parkaposht	17.5±5.5	-4.003	0.000
	Safrabasteh forest park	24.3±11.3		

Table 3. Mean±SD of *Populus caspica* and *Alnus glutinosa* breeding.

Species	Region	Mean±SD	t	Significance
Populus caspica	Parkaposht	6.8±1.7	3.438	0.002
	Safrabasteh forest park	0.1±0.04		
Alnus glutinosa	Parkaposht	7.9±5.7	-1.178	0.244
	Safrabasteh forest park	9.9±7.1		

Soil physical properties. Results showed significant differences on some soil physical properties among the regions. Results did not show significant differences on clay and P.D, while the other soil physical properties showed significant differences (Table 4).

Correlation breeding between Populus caspica and Alnus glutinosa with soil physical properties. Results of Pearson correlation coefficient between regeneration of *Populus caspica* and *Alnus glutinosa* species with soil physical properties have been shown in Table 5. Among the soil physical properties, B.D and WHC showed positive of negative correlation with *Populus caspica* breeding, respectively.

Discussion

Regeneration of *Populus caspica* is significantly higher in Parkaposht region than in Safrabasteh forest park, also should be noted that in both areas the regeneration of *Alnus glutinosa* is happened.

Table 4. Mean±SD of soil physical properties.

Soil properties	Region	Mean±SD	t	Significance
Silt, %	Parkaposht	39.02±3.87	4.908	0.000
	Safrabasteh forest park	47.05±7.86		
Clay, %	Parkaposht	13.82±3.52	1.804	0.076
	Safrabasteh forest park	16.32±6.72		
Sand, %	Parkaposht	46.88±6.08	-5.292	0.000
	Safrabasteh forest park	36.63±8.82		
B.D, g cm^{-3}	Parkaposht	1.34±0.13	-5.901	0.000
	Safrabasteh forest park	1.17±0.09		
P.D, g cm^{-3}	Parkaposht	2.28±0.53	-0.165	0.870
	Safrabasteh forest park	2.26±0.12		
SP, %	Parkaposht	37.31±17.00	3.183	0.002
	Safrabasteh forest park	47.69±5.46		
WHC, %	Parkaposht	45.03±2.57	23.781	0.000
	Safrabasteh forest park	84.77±8.87		

Legend: B.D-bulk density, P.D-Particle density, WHC-water holding capacity, SP-soil porosity

Table 5. Pearson correlation coefficient and significant level between *Alnus glutinosa* and *Populus caspica* breeding with soil physical properties.

Soil properties	Correlation coefficient	*Populus caspica* breeding	*Alnus glutinosa* breeding
Silt, %	Pearson correlation	-0.178	0.249
	Sig. (2-tailed)	(0.173)	(0.055)
Clay, %	Pearson correlation	0.082	0.055
	Sig. (2-tailed)	(0.535)	(0.676)
Sand, %	Pearson correlation	-0.175	-0.150
	Sig. (2-tailed)	(0.180)	(0.252)
B.D, g cm^{-3}	Pearson correlation	0.254*	-0.105
	Sig. (2-tailed)	(0.050)	(0.425)
P.D, g cm^{-3}	Pearson correlation	0.011	-0.066
	Sig. (2-tailed)	(0.935)	(0.617)**
SP, %	Pearson correlation	-0.161	0.004
	Sig. (2-tailed)	(0.220)	(0.975)
WHC, %	Pearson correlation	-0.384*	0.186
	Sig. (2-tailed)	(0.049)	(0.154)

Legend: **significant level $p<0.001$; *significant level $p<0.05$

Based on the results, it was found that in both regions there are sufficiently trees of *Alnus glutinosa* and *Populus caspica*. Although the *Populus caspica* in Parkaposht is more than 3 times of *Alnus glutinosa*, there are sufficient trees of *Alnus glutinosa* produced each year (270 trees per hectare).

Also in Safrabasteh forest park, the number of *Alnus glutinosa* is about 5 times rather than the number of matures *Populus caspica*. However, there are sufficient mature trees of *Populus caspica* (103 trees per hectare) in this region.

Besides effective environmental factors, appropriate mature trees that are able to produce sufficient seed for the regeneration, are one of the main factors in the regeneration of tree species. This study showed that in both regions, the seed trees are suitable for regeneration, although the mean diameter of *Populus caspica* and *Alnus glutinosa* in Safrabasteh forest park is far higher than in Porkaposht region.

In addition to the origin and characteristics of the seeds, some of the natural factors such as lighting, climate, topography and soil characteristics, are effective in the regeneration. Soil properties such as soil texture, porosity, moisture and soil carbon and nitrogen content, are the most important factors that effect on natural regeneration and seed growth (OLESKOG & SAHLEN, 2000; SALEHI *et al.*, 2011). Differences between physical properties of soils in the two regions could be related to several factors. In this study, it seems that the location of the study regions is one of the main factors influencing the difference soil properties specially soil physical properties.

Parkaposht region has been located near the river and is affected by river sediments. Existed soils have generally evolved on the sediments and have their own characteristics. This type of soil is not very deep; generally have a light texture and are not fertile. Based on the results, soil texture was lighter in Parkaposht region and sand proportion is higher than Safrabasteh forest park. High sand and low clay content results in good aeration, but on the other hand, causes the lack of water and the absorption of nutritional elements. With considering soil conditions and the differences between two areas, it can be stated that the condition of soil properties and specially the existing of nutritious in Safrabasteh forest park are more suitable for the growth of plants than those in Parkaposht area of Safrabasteh forest park. MADSEN & LARSEN (1997) stated that soil moisture has a positive effect on the establishment and growth of European beech seedlings.

According to the study in both Safrabasteh forest park and Parkaposht region, there are enough *Populus caspica* trees. Although in Safrabasteh forest park the regeneration of *Populus caspica* has been less observed, the base of *Alnus glutinosa* is higher and its regeneration is more. In addition to the *Alnus glutinosa* in Safrabasteh forest park region, the tree and the regeneration of *Pterocarya fraxinifolia* and *Gleditschia caspica* can be seen, while it is missing in Parkaposht region.

It can be concluded, that in Safrabasteh forest park the soil has an appropriate condition, especially in terms of content nutrition. Although in Safrabasteh forest park there are enough *Populus caspica* beside other seed trees, the existence of the other species and their regeneration is the better competition against *Populus caspica.* In other words, we can say that in Parkaposht region, where the soil is nearly poor representing fertility, some species such as *Alnus glutinosa* grow less or not at all, but *Populus caspica* has been able to grow better there.

On the base of the results of this study, it can be concluded that the regeneration of *Populus caspica,* as an endemic and useful tree species, does not need a very favorable soil physical properties. It seems that *Populus caspica* can even grow in fertile soils with favorable physical condition, but in comparison to other tree species it have not been able to be established in this situation.

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